A.D. 1856 . . . . N° 3059.

Electric Telegraphs.

LETTERS PATENT to Cromwell Fleetwood Varley, of 2, Gloucester Terrace, St. Paul's Road, Islington, in the County of Middlesex, Telegraphic Engineer, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEGRAPHS."

Sealed the 23rd June 1857, and dated the 24th December 1856.

PROVISIONAL SPECIFICATION left by the said Cromwell Fleetwood Varley at the Office of the Commissioners of Patents, with his Petition, on the 24th December 1856.

I, CROMWELL FLEETWOOD VARLEY, of 2, Gloucester Terrace, St. Paul's Road, Islington, in the County of Middlesex, Telegraphic Engineer, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHS," to be as follows:—

Firstly, I use a soft iron needle free to move inside coils of wire, which needle is deflected by exterior permanent magnetism accordingly as the former is magnetized. These needles are used for the indicators of telegraphs, and also for completing or opening local circuits. I also use moving coils of wire, the needle and magnet being fixed. These coils I use to actuate local circuits, as also to act as indicators. I also use a magnet inside instead of soft iron, according to the use to which the moving coil is to be applied.

Secondly, an improved key, which will send reversed or opposite currents or single currents, like the Morse key, at the operator's will without the use of a

separate switch, thus enabling the operator with one hand and one handle to work; the key when not sending currents re-establishes the communication between the conducting wire and the relay.

Thirdly, I also use the electricity obtained from induction coils of the following improved constructions. The iron core is made of an endless piece or pieces of iron or iron wires instead of the forms hitherto used.

Another mode of effecting this object is to make a series of flat bars of iron or handles of iron wires, which are arranged so that the alternating magnetic poles are of the reserve name.

These poles are sometimes joined together, completing the magnetic chain, as in the former case. The before-mentioned iron cores are covered with one, two, or more independent layers of insulated conducting wire for obtaining induced currents.

Another feature in these improvements consists in employing "thermo-electricity" to produce induced currents. I use induction plates to prevent burning at the relay or other contacts. I so far modify my battery, patented December 5th, 1854, No. 2555, that fresh neutral salt can be added without stopping the action of the battery.

The galvanometer I propose to employ is wound with two layers of insulated wire, the action of either of which can be suppressed at will. I thus make one galvanometer answer the purpose of two of the ordinary construction. I prefer a needle of a disc-shape form, mounted on knife edges, and so arranged as to render it easily magnetized.

Another improvement, and which relates to "step-by-step motion telegraphs," consists in using opposite or reversed currents to produce the letters or signals, and a series of currents in one direction instead of alternate currents for bringing the machines to zero.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Cromwell Fleetwood Varley in the Great Seal Patent Office on the 24th June 1857.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, Cromwell Fleetwood Varley, of 2, Gloucester Terrace, Saint Paul's Road, Islington, in the County of Middlesex, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Twenty-fourth day of December, in the year of our Lord One thousand eight hundred and fifty-six, in the twentieth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the

said Cromwell Fleetwood Varley, Her special licence that I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, or such others as I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Electric Telegraphs," upon the condition (amongst others) that I, the said Cromwell Fleetwood Varley, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Cromwell Fleetwood Varley, do hereby declare the nature of the said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say :—

My Invention consists of the following improvements, and in the mode of applying them. I will describe the apparatus first, and the mode of applying them afterwards.

In order to explain my said Invention as completely as possible, I now proceed to describe the best means I am acquainted with for carrying the same into practical effect, reference being had to the illustrative Drawings hereunto annexed, and to the numeral figures and letters of reference marked thereon respectively, as follows, observing, that in the Drawings attached the contact screws and other subordinate pieces of mechanism common to all apparatus of this description, well understood and unnecessary to the explanation, are generally omitted, in order to make the Drawings clearer.

Figures 1, 2, 3, 4, and 5 show improved coils and needles, which are here shown applied to relays. Figure 1 is an elevation ; Figure 2 a birds'-eye view ; Figure 3, a similar view ; Figure 4, a vertical section ; Figure 5, a birds'-eye view. The letters of reference are the same for these five Figures.

a, the axle and pivots on which the needle *n*, *s*, is mounted ; *b*, coils of fine wire wrapped on a frame in the usual manner for a galvanometer ; *c*, iron cores, extending inside the coils *b* as far as *f*, *f* ; *d*, iron cheeks to the coils *b* ; *e*, iron casings connecting the cheeks *d*, *d*, together ; *f*, the interior surfaces of the iron cores *c*, *c* ; *g*, platinum wire, projecting into *h* (in Figure 4 only) ;

h, an iron cup containing mercury; *i*, platinum contact piece; *k*, set screws, acting as stops to limit the play of *i*, and also to make contact; *l*, a piece of glass or other non-conducting material inserted in one of the screws *k*; *m*, space between the iron cores *c*, *c*, (in Figures 1 and 2 only); *n*, *s*, the needle to be deflected; N, S, poles of a strong permanent magnet; *o*, a division through the iron casing, as at Figure 3; *p*, ends of the wire composing the coil *b*; *q*, iron saddles, connecting the iron casings *e* with the poles of the magnet N, S, Fig. 2; *r*, division between the coils (in Figure 1 only).

In Figures 1 and 2 the iron needle *n*, *s*, receives its magnetism by induction from the poles of the large magnet N, S, in the following way:—The magnetism of the pole of the large magnet S induces magnetism of the like nature in *e*, *d*, and *c*, and the pole N acts in the same manner upon e^1, d^1, and c^1; *f*, *f*, becoming southern poles and f^1, f^1, northern poles, these in turn induce magnetism in the needle *n*, *s*, (which in Figures 1 and 2 is generally made of soft iron.) When a current of electricity is circulating through the wire and coils *p*, *b*, the needle *n*, *s*, endeavours, in compliance with a well-known law, to stand at right angles by the direct action of the electrized wire; so far the action is similar to that of the relay, previously patented by me, the said Cromwell Fleetwood Varley, on the 16th day of February 1854, No. 371. The electric current acts upon the iron cores *c*, the cheeks *d*, and the casing *e*, forming an electro-magnet, whose poles are at *f*, *f*. The electro-magnet or magnets thus formed act also on the needle, causing it to deflect with more power than if the iron were not there. The iron work is divided as shown at *m*, in order to cause magnetism to be induced in the iron needle; such needles are very sensitive to electric currents, and have this great advantage, that powerful currents and lightning discharges cannot demagnetize them.

In Figures 3 and 4 the coils are round, and the needle of the shape shown in Figure 5. Here the same principle of surrounding the wire of the coil with iron is shewn applied to a permanently magnetised needle. In this case the iron is not divided, as in Figure 1, but covers the entire coil, thus developing more magnetism, and giving a little more power than in the arrangement shewn in Figures 1 and 2; such a needle, however, can be demagnetised by the passage of a powerful current. The iron is cut through at *o* to prevent the formation of secondary currents in the iron *e*, *d*, and *c*, which would partially neutralize the action of the original current. Where these relays are used to complete local circuits, including a powerful battery, I use the platinum wire *g*, dipping into the mercury in the cup *h*, which make a better contact than the pivots alone would. When these are used for indicators, in which case they will have considerable play, the cores *c*, *c*, are partially or entirely removed, according to

circumstances. In Figures 1 and 2 the coils are made in halves, as shown at *r*, to admit the needle *n*, *s*, and axle *a*. I do not, however, confine myself to the shapes represented in the foregoing Figures.

Figures 6 and 7 shew another arrangement by which the soft iron needle can be used for the foregoing purposes. Figure 6 is an elevation; Figure 7 is a birds'-eye view. *a*, axle carrying the needle *n*, *s*; *b*, coils of wire; *c*, pieces of iron placed on each side of the coils, to which are attached the magnets N, N, which latter are shown in Figure 6, but omitted in Figure 7; *d*, an adjusting piece carrying the set screws *k*, *k*; *e*, base board, only partially shown; *f*, an index point running over the scale *g*; *g*, the scale; *h*, handle to move the piece *d*; *i*, piece of platinum attached to needle to insure clean contact; *k*, a set screw tipped with platinum; k^1, a set screw containing a piece of non-conducting material *l*, and acting as a stop to *n*, *s*; *l*, piece of non-conducting material; *m*, uprights carrying the screws *k*; N, permanent magnets; *n*, *s*, needle; *o*, screw on which the piece *d* turns as a centre; *p*, ends of wire projecting from the coils *b*, *b*. In this arrangement the iron needle *n*, *s*, is placed between the two pieces of iron *c* N,—*c* S, which latter are by continuation the north and south poles of the permanent magnets. When placed exactly in the centre each pole of the permanent magnet acts equally upon the needle, but the moment a current of elasticity circulates through the wire *b* magnetism is developed in the iron needle, which is deflected accordingly. When the needle is deflected so as to rest against k^1 the local circuit is open, the current cannot pass through the non-conducting glass *l*; but when the needle is so deflected as to rest against *k* the local circuit is closed, and the local current flows in the usual manner, which being well understood I need not describe more fully.

Figures 8, 9, and 10 represent a mode of using moveable coils and fixed magnets for either relays or indicators. Figure 8 is a birds'-eye view; Figure 9 is a side view of Figure 8. Figure 10 is a birds'-eye view of another form in which a single instead of a double coil is used. The letters of reference are the same for all three Figures. *a*, axle carrying the moveable coils of wire; *b*, *b*, coils of wire; *c*, pivot holes in which *a* works; d^1 a magnetic horse-shoe; *e*, iron ends, acting as poles to the magnet *m*, and surrounding as much as possible the moveable coils *b*. The horse-shoe *d* (may be made either of soft iron or a permanent magnet). The peculiarity of this arrangement consists in placing magnets both inside and outside the coil, and surrounding the latter as much as possible, so as to concentrate the magnetic rays through the coil of wire *b*, which greatly increases the deflecting power,

and also preserves the magnetism in the permanent magnets. These moving coils can be used for relays instead of a moving needle; as they contain but very little wire they offer but little resistance to the passage of a current, and are in consequence very useful where many instruments are included in one circuit.

I prefer using aluminium wire for these coils, because it is, weight for weight, a much better conductor than copper or silver. The ends of the wire coil *b* are connected to the line wire either by hair springs, by platinum dipping in mercury, or by dividing the axle in half and insulating the halves, the two ends of the wire in the coil being united to them respectively, the circuit in this latter case being formed through the pivots. In Figure 10 one coil is used, and the piece *d* is a block of iron or magnetised steel with a hole through it or slot cut half through it to admit the axle *a*.

I would here remark, that I am well aware that Baines has used moving coils for "step-by-step motion" telegraphs; what I claim as my Invention is, the placing permanent magnets so that the magnetic rays are concentrated through the coils of wire, whereby greater deflection is produced, and the permanent magnets rendered less liable to lose their power. I further claim the application of moving coils to telegraphic relays.

Figures 11 and 12 represent my double-action galvanometer, which enables the operator to measure either his own current or the current received from another station. Figure 11 is an elevation; Figure 12 is a birds'-eye view. *a*, knife edges on which the needle is mounted; *b*, coils of wire; *c*, grooves in which the knife edges work; *d*, indicator attached to the needle *n*, *s*; *e*, scale, in front of which *d* travels; *f*, glass cover to keep out the dust; *g*, base board on which the whole is mounted; *h*, *i*, terminals in connection with the inner wire; *k*, *l*, terminals in connection with the outer wire; *m*, *n*, holes into which the plug *o* fits; *o*, metallic plug for making short circuit. The coil *b* consists of two distinct wires; the one first wrapped on, and whose ends are connected with *h*, *i*, is longer than the wire in the second coil, whose ends are connected with *k*, *l*. I generally arrange them in such proportions that a current, which, when passing through the wire *k*, *l*, produces about 5° of deflection, shall, when passing through *h*, *i*, produce 15°. When the plug *o* is placed between the two half holes *m* it makes a short circuit from *k* to *l*. The hole *n* is to receive the plug when the wire b^1, b^1, is being used. The apparatus is connected as follows:—The line wire is connected to terminal *l*; terminal *k* is connected through the key and through the relay with the terminal *i*; terminal *h* is connected to the earth or to the other line wire.

Call the station at which this instrument is placed A, and the station with which it is in communication B. When B is sending a current it passes through the line wire to l, through the wires b^1, b^1, to k, thence through key and relay to i, through the longer wire b, b, to h, and to earth. When A is sending a current it passes from the key to k, and through the shorter wire b^1, b^1, only to l, and to line. If the plug be placed at m the current goes direct from k to l without traversing the wire b^1, b^1, and consequently produces no motion of the indicator d; in this state the action is like that of an ordinary galvanometer, and shews only the received currents. On long lines the loss of electricity is generally considerable, consequently the current when it arrives at station B is much weaker than when it left station A. In my galvanometer the current leaving station A circulates only through the shorter wire b^1, b^1, in connection with k and l, while at the station B it passes through both wires. By this means I bring the strong sending and the weaker received currents within the range of the same galvanometer. Hitherto it has been necessary to employ two galvanometers, one more sensitive than the other, for this purpose.

Another feature in this part of my improvements consists in polishing the surface of the needle, and placing it near the top of the coil b, b. This is very useful at night, as it calls attention by reflecting a spot on the ceiling, and by day the motion of the polished surface attracts the eye quicker than the motion of an ordinary needle.

Figure 13 represents a self-switching key which will send either single currents, like the Morse key, or reversed currents, at the operator's will. Figure 13 is a birds'-eye view. a, centre, on which the key turns laterally; b, a terminal in connection with the line wire; c, a terminal in connection with the copper pole of a battery whose other pole is to earth; d, stop piece in connection with the terminal R, and on which the key bears when at rest in the oblique position; e, f, stop pieces in connection with the terminal c; g, stop piece in connection with the terminal Z; h, axle on which the key moves vertically; i, handle of key; R, terminal in connection with relay; Z, terminal in connection with the zinc pole of a battery whose other pole is to earth. This key is similar in shape to a Morse key, but turns upon the centre a, and is retained in the oblique position by a spring and stop underneath the base board (not shewn but easily understood). The key can be pulled laterally into the position shewn by the dotted lines, there being a second stop, not shewn, to prevent its going further to the left than this. This key when in the oblique position, and when elevated and

depressed, for sending a message, as with the Morse key, bears alternately upon the stop pieces *e* and *d*, but when pulled to the left, as shewn by the dotted lines, and then elevated and depressed, bears upon the stops *f* and *g*. In the former position, when the handle *i* is depressed the line wire is connected to the copper terminal *c*, and a positive current flows down the line; when elevated, the line is connected to the relay; in this position it acts exactly like a Morse key; when held to the left and depressed, a positive current flows down the line, as before, but when elevated a zinc current flows down the line. When the alternate currents only are required, I make the pieces *d* and *e* incline planes, as shown at d^1, e^1, Figure 13 A, and connect them both with terminal *r*, making a double and much surer contact with the relay than is the case with the common Morse key. This key does not require a separate switch to connect the line to its relay when the operator has finished his communication to a station.

Figures 14, 15, 16, 17, 18, and 19 show improved introduction coils. The letters of reference show corresponding parts in all these Figures. Figures 14, 16, 17, and 19 are sections; Figure 15, an end view; Figure 18, an elevation. *a*, primary wire; *b*, secondary wire; *c*, an iron box (in Figure 15 only); *d*, insulator between the secondary wire *b* and the iron wires *i* (in Figure 14 only); *e*, ends of secondary wire; *f*, ends of primary wire; *g*, glass tube; *h*, glass discs; *i*, iron cores; *k*, *l*, junctions of parcels of secondary wire *b* (in Figure 19 only); *m*, saw cut in iron to prevent the formation of secondary currents in the iron itself (in Figures 17 and 18 only). In the coil represented in Figure 14 the bundle of iron wires instead of being made of about the same length or a little longer than the coil, as has hitherto been done, is made of rather more than three times the length, and its ends are bent back, as shown in the Drawing, so as to encase the whole coil with iron wire, excepting a small space purposely left (not shewn in the Drawing) through which the ends of the primary and secondary wires pass. By thus encasing the coil with iron the quality of electricity circulated in the secondary wire is very much greater than when the iron is removed.

Figure 15 shows another form of induction apparatus, and consists of a series of flat iron cores, whose ends are shewn at N S, N S, N S. *a*, *a*, represents the primary, and *b*, *b*, the secondary wire. These are so wrapped that the current circulates through them in the manner shewn by the arrows, producing alternate poles, as represented by N S, N S. In this arrangement the secondary wire is placed between two primary wires and between two iron cores, and the primary wire acts upon the iron cores on each side of it; by

this means great power is obtained in the secondary wire. But to make this coil complete, I cover it again with iron box *c, c, c, c,* which has corresponding iron ends (which are removed to show the construction of the coil); by this means I get very great effects from small battery power and a small quantity of wire. An opening in the iron case *c* is left to admit the ends of the primary and secondary wires.

Figure 16 shows another mode of making induction coils. Here the primary wire is wrapped in separate portions a, a^{1}, a^{11}, a^{111}, all, however, electrically connected in one continuous series; the intervening spaces are filled up with secondary wire, which is continued above a, a^{1}, a^{11}, a^{111}, as shown at *b, b, b.* I have represented this principle as applied to a coil of the ordinary shape, but when applied to the coils shewn by Figures 14 and 15 I have obtained more induced current from a given amount of battery power than from any other arrangement; but by this plan a considerably larger amount of secondary wire is required. With all of these improvements combined I can work moderate distances by means of thermo-electricity. The forms of induction apparatus shown in Figures 14 and 15 do not show any sensible quantity of magnetism outside of them, the magnetism being nearly all neutralized. The coils of the usual form, when of large size for working long lines, will affect magnetic needles many yards distant, and consequently the induction coil cannot be used in the same office that relays are being worked in. My improved coils obviate this difficulty, and several of them may be used in the same office that relays are being worked in without the latter being interrupted.

Where the inductive coils are to be used with condensers to produce electricity of very high tension, I construct the coils as shewn in Figures 17 and 18, or that shewn in Figure 19, using glass to insulate the secondary wire from the primary. In Figures 18 and 19 the iron core *i, i,* is wrapped with primary wire, the glass discs *h, h,* are then put on the two iron discs *i, i,* attached, the primary wire wrapped between the glass discs *h* and the iron ends *i,* and, lastly, the space between the glass discs *h, h,* is filled with secondary wire, the inner end of which is soldered to the primary wire before being wound on. The iron discs are split, as shewn at *m,* to prevent the formation of secondary currents in the iron work. By increasing the diameter of this coil, the length of spark will be increased without the distance between the primary and secondary wires being augmented, the glass maintaining the insulation.

Figure 19 is a section, shewing another mode of applying glass as an in-

sulator for coils. *g, g, g, g,* represent a glass tube containing an iron core *i, i, i, i,* wrapped with primary wire *a*, only part of which is shewn, the secondary wire *b* being wrapped outside the glass tube and between the discs of glass *h, h, h, h.* The secondary wire, on being wrapped on the glass tube *g, g,* is wound in the same direction between the first, third, fifth, &c. pairs of glass discs, and in the opposite direction between the second, fourth, sixth, &c. pairs of glass discs. The inner ends of the first and second, third and fourth, and fifth and sixth helices of wire are connected together, as shewn at *k, k, k,* and the outer ends of the second and third, fourth and fifth helices are connected together, as shewn at *l, l,* leaving the outer ends of the first and sixth as the terminals of the secondary wire. By thus dividing the secondary wire into small parcels, the tendency of the electricity to jump from wire to wire and make short circuits is proportionately reduced. In some cases a large glass tube may be slipped over the discs *h, h,* and iron wires placed outside it, these last being insulated from the secondary wire by the tube. These iron wires cause an increased quantity of electricity to circulate through the secondary wire, and operate the same as Figure 14. In making powerful coils, I prefer using wire whose section is square, triangular, or parallelopiped, so that when wrapped together the smallest possible amount of space is lost.

In Figure 19 part of a square primary wire is shewn in section. Instead of solid wire, a number of wires may be drawn together, so as to fill up the spaces between them, thus forming a bundle whose section is that of any of the forementioned shapes, and uniting the conductability of a large wire with the flexibility of a smaller one. For some purposes I wrap these coils entirely with fine wire, the use of which is described in Figure 26; these I term primary coils. Where the depth of secondary wire is considerable, I sometimes use thinner wires for the inner layers than for the outer, increasing the substance of the wire gradually as the inductive action decreases by reason of the distance between the outer wire and the iron core. By thus progressively enlarging the wire, the action throughout the coil is equalized, and much more power is obtained than when wire of the same size is used throughout. This is scarcely necessary in the arrangement shewn in Figure 15, where each secondary wire is placed between two primary wires, which produces a much greater equality of action. Hitherto it has been the practice to make the secondary wire of one size throughout; I sometimes wrap the coils of relays and of indicators in the same manner.

Figure 20 represents a key to be used with induction coils. Figure 20 is an elevation. *a* a key, very similar to a Morse key, but carrying *b*, the

projecting arm, supporting c, the ivory commutators; d, e, stops on which the key rises and falls; f, socket in which the key plays; g, spring to elevate the key; h, pivot on which the key works; i, handle of key; k, upright pillars carrying the springs l^1, l^2, l^3, l^4; l, springs, also shown in birds'-eye view underneath Figure 20; m, pieces of platinum or other metal fixed on the ivory bar c; n, piece of platinum on the end of spring l; p, primary wire of induction coil; s, secondary wire of induction coil. In the birds'-eye view the springs l^1, l^2, l^3, l^4, are broken off to give a better view of the commutator c. m^1 and m^3 are connected together, as shewn by the dotted line, by a strap of metal, but are insulated from the other pieces. The object of this key is to use the currents generated both by the breaking and by the making of the circuit of the primary wire of the induction coil. When the handle i is elevated, a current from the battery is flowing through the primary wire p of the coil, but upon slightly depressing the key the circuit is broken, when a current is induced in the secondary wire s. Upon the key reaching e, a current again flows through the primary wire p, inducing in the secondary wire s a current in the opposite direction; but as the commutator c has changed the connection with the line, this current flows down the line in the same direction as the previous one. On elevating the key a two more currents are produced, which circulate through the line in the opposite direction to the former two. When the key is elevated the spring l^1 is resting on m^1, which, being in connection with m^3, connects it with l^4; l^2 and l^3 are resting on m^2, and are therefore connected together. On depressing the key, l^1 and l^2 rest on n^4, while l^3 and l^4 rest on m^5, thus while depressing and elevating the key the necessary changes are made. By this key the effect of the induction coil is nearly doubled. A switch, not shown, cuts off the battery when not required, and also connects the line to the relay for receiving communications.

Figures 21 and 22 represent another form of key for working with induction coils through long submarine wires. Figure 21 is a birds'-eye view; Figure 22 is a side view; but the cam wheel c is twisted a quarter round on the axis g to show the change of connections in the commutator. a, handle; b, cam wheel; c, commutator wheel; d, contact piece, on which the spring e rests when it is not lifted off by the cam wheel b; e, spring above mentioned; f, cock through which the axis g passes; g, axis, carrying a, b, and c; h, pillar, carrying the spring e; i, knob to handle; k, spring in connection with terminal R; l^1, l^2, l^3, l^4, springs, similar to those in Figure 20; m^1, m^2, m^3, m^4, m^5, for a similar purpose to those in Figure 20; n, pieces of platinum; o, boss, in which the axis g turns; p, base board. The object of this key is to send a

large number of induced currents down a line, so as to combine their effects. The cam b is insulated from the axis g, and elevates the spring e, according to the arrangement exhibited, six times in a revolution. The spring e completes the circuit of the primary wire when resting on d, and when lifted off breaks it; consequently every revolution of the handle a produces twelve currents in the secondary coil, six in one direction and six in the other. The commutator wheel c carries a series of commutators, similar to those shown at c, Figure 20, with four springs l^1, l^2, l^3, and l^4, and whose ends are shewn at Figure 22, but removed from Figure 21, resting against them, similar to those shown in Figure 20. The commutators are so arranged, that upon the handle a performing part of its revolution, the first half or more of the currents pass down the line in one direction and the remainder of the currents in the opposite, thus a series of currents in one direction I use to produce one signal and a series of currents in the opposite direction, to produce the interval between two signals. The commutator wheel c is exhibited turned a quarter round, to show that part which causes the currents to travel in the opposite direction. The action of this commutator will be better understood on reference to Figure 20.

The commutator wheel is made of hard wood, ivory, or other non-conducting material. The pieces marked m^1, &c. are insulated from each other and from the axle g, and are connected like those in Figure 20. The line wire, in addition to being connected with l^4, is connected to the handle a via f, o, and g. This key is chiefly of use for working through very long submarine lines, where the correspondence must be carried on at a slower speed than usual, and great electric power is required to produce a signal. To print a dot with this key, the handle a must be carried round from right to left; if taken round twice two dots will be produced, and so on. To produce a dash, the handle a must be allowed to pause for a moment over the terminal R before completing the revolution.

I am well aware that Wheatstone and others have used a series of magneto-electric currents in one direction to produce letters on a step-by-step motion telegraph; what I claim, therefore, as my Invention is, the use of a series of currents (three or more) in one direction from an induction machine, to produce each mark on a recording telegraph, whose alphabets are produced by a combination of one or more of those marks, as in Morse's and Baines's alphabet, &c., viz., *e*, *i*, *s*, *h*, 5, . also of a series of currents to discharge

- -- --- ---- ----- -- -- --

the line and produce the interval between the marks. By this means I make a much smaller battery and induction apparatus, sufficient for working long

submarine wires, than would be necessary were not a series of currents used; and, further, I render the insulated wire less liable to become damaged, because the currents used are not of such high tension. When the tension is very high the gutta percha covering is in danger of being injured by the same, especially if any slight defect exist in the insulated covering.

Figures 23 and 24 represent another form of relay which I sometimes use with the induction coils. Figure 23 is a side view; Figure 24 is a birds'-eye view. *a*, axle; *b*, electro-magnets, standing on *c*; *c*, iron plate; *d*, poles of electro-magnet; *e*, pieces of iron attached to *d*; *f*, piece of iron mounted on pivot *a*; *g*, cock receiving the upper pivot of *a*; *h*, contact screws, tipped with platinum; *i*, pieces of platinum; *k*, enlargement of the bar *f*, *f*; *m*, permanent magnet. The permanent magnet *m* induces magnetism in the iron bar *f*, *f*, and in the iron of the electro-magnets through the iron plate *c*, as shewn by the capital letters N, S; the iron bar *f* is therefore attracted most powerfully by that pole to which it is nearest. The magnets *b* are so wound that the poles are of the order shown by the little letters *n*, *s*, *n*, *s*. When a current of electricity circulates round *b*, the iron bar *f* is repelled by the two northern poles and attracted by the two southern. By reversing the currents, the bar *f* is thrown from side to side, and remains on that side to which it was last attracted. A spring or small separate permanent magnet, not shown in the Drawing, may be used to give the necessary bias to the one side or the other, or the contact screws *h*, *h*, may be mounted as in Figure 7. For some purposes it is necessary that the piece *f* should stand clear of the screws *h*, *h*, when no current is passing; this I effect by magnetising the electro-magnets *b* and the piece of iron *f* by the same pole of the permanent magnet. The piece *f* is then repelled by the electro-magnets, and stands between them until a current passes, when it is deflected to the one side or the other, according to the direction of the current. This relay cannot be demagnetized by a flash of lightning or other powerful current. In the latter form the piece *f* can be used for the needle of a needle instrument; it is particularly useful for railway signal instruments.

Figure 25 represents a step-by-step motion telegraph to be worked by alternate currents, similar to those generated by induction coils, and with an arrangement to bring the pointer to zero. Figure 25 is a side view. *a*, axle, carrying a needle inside the coil, similar to that in Figure 7; *b*, an electro-magnet; *c*, its armature; *d*, iron composing electro-magnet; *e*, thick copper tube outside electro-magnet; *f*, piece projecting from *g*, and carrying the upper pivot of *a*; *g*, bar carrying the armature *c*; *h*, axle carrying *g*; *i*, spring to press *g* against the stop screw *k*; *k*, *l*, stop screws, partially shown; *m*,

escape wheel, attached to a clock train; *n*, palletts, which prevent *m* from running round; *o*, a piece projecting from *g*; *p*, pin projecting from *m*; *q*, fine wire surrounding *b* and *r*; *r*, coil, somewhat similar to that shewn in Figure 7. The electro-magnet consists of an iron horse-shoe *d*, placed inside a copper reel, on which the wire *q* is wound. Outside the copper reel and wire *q* are placed the copper tubes *e*. The effect of the copper round the iron is to allow of the formation of secondary currents in them when currents are circulating in the wire *q*. These secondary currents, being in the opposite directions to the first, neutralize them to a great extent, and retard the development of magnetism in the iron *d* so considerably, that the momentary alternating currents from an induction apparatus or magneto machine will not attract the armature *c*. These alternating currents, however, in passing round the coil *r* deflect the needle *n*, *s*, backwards and forwards, allowing the toothed wheel *m* to escape in the usual way; but by introducing a commutator in the circuit which causes the currents to flow down the line in one direction the needle *n*, *s*, will remain stationary on one side, while the armature *c* will now be attracted, removing the pallets n^1, n^2, from the toothed wheel *m*, which will fly round until the pin *p* rests upon the stop *o*. Thus alternate momentary currents allow the wheel to progress step by step, while several currents in the same direction allow the wheel *m* to run on to zero. It is not necessary to describe the commutator here, as that form attached to ordinary magneto machines, which is generally used to give currents in one direction or alternating currents, will answer the desired end.

Figure 26 represents a key for working with a primary coil only. Figure 26 is a side view. *a*, metal work of key; *b*, stop against which the spring *c* rests; *c*, spring, which when the key is pressed down bears on *e*; *d*, stop piece in connection with relay; *e*, stop, similar to *d*, but in connection with one pole of a battery, whose other pole is to earth; *f*, supports between which *a* works; *g*, spring, which elevates the handle *a*, *i*; *h*, pivot, on which handle works; *i*, knob of handle; *k*, battery; *l*, primary coil, wrapped only with one kind of wire (similarly to the secondary portion of an induction apparatus, vide Figures 14 and 15). The line wire is connected to *f*, and when the key is at rest it is connected to the relay at *d*. When the handle is depressed, the line is firstly disconnected from the relay, secondly it rests upon the spring *c*, thirdly it presses the spring *c* upon *e*. In this position the current from the battery *k* splits, part flowing down the line, part going from the primary coil to earth. Upon elevating the key the contact with the battery is first broken, at which moment a current is induced in the coil *l*, which, being in the same direction as that which was flowing through it, causes a momentary current to flow through

the line in the opposite direction to the original current. This is of great use for submarine lines, for on the first moment of making contact the coil opposes a greater resistance to the current while it is being magnetized than when it is charged, consequently the current flowing down the line is more intense at the first moment than afterwards; this neutralizes to a considerable extent the effect of induction in the line wire, while the reverse current discharges the line. For overground wires, working with Morse or other relays, a beneficial effect is experienced, enabling the communication to be carried on more rapidly. I use the same general arrangement for translation.

Figure 27 represents a new disposition of apparatus which I use for translating alternating currents from one line to another. a, a^1, writing levers of Morse machines, and connected with the line wire, as shown; b, b^1, apparatus, similar to those in Figures 23 and 24; c, d, batteries connected, as shown; e, e^1, points of writing levers; f, f^1, same as f in Figure 24; g, g^1, stop screws, in metallic connection with f, f^1; h, h, stop screws, in connection with the relays working the Morse machines; i, i^1, stop screws, in connection with the zinc pole of a battery whose copper pole is to earth; k, k^1, stop screws, in connection with the copper pole of a battery whose zinc pole is to earth. The magnets actuating f are so constructed as to offer a great resistance compared with the line.

Action.—Upon the lever a^1 being depressed, a positive current flows down the line, part of it going to earth through the coil of f^1; this current deflects the piece f^1 against i^1; when a^1 rises and touches g^1, a negative flows down the line, splitting as before and throwing back the piece f^1 against h^1, when the line is again connected to its relay. It will be evident that the latter current is but of momentary duration. By this disposition of apparatus a positive current traversing one line causes a positive current to flow down the other line, followed by a negative current of short duration, which is very useful for neutralizing the effects of the charge in submarine cables and subterranean wires; it is also good for overground wires. For working a single line (when not translating) a Morse key must be substituted for the lever a.

Figure 28 represents a new mode of working through long submarine wires, whereby the speed of the electric wave is increased. a, a^1, batteries opposing each other, and of such strength that no current, or almost none, passes through the relay b^1; on causing currents from the induction apparatus to traverse the wire, the waves of electric force will travel to the distant end and act upon the relay more speedily than when the batteries a are not connected to the line. The two batteries a, a^1, hold the wire in a state of electric tension,

and the waves of electric force imparted to the wire travel through it with increased rapidity. When the wire is perfectly insulated the batteries at both ends must be of equal power. When not perfectly insulated, the battery a^1 must be so strong that it absorbs all the leakage, and just balances the battery a at b. I am well aware that Mr. Walker has used opposed batteries for railway signals, which latter are produced by connecting the line with the earth, but I am not aware of opposed batteries having heretofore been used for accelerating the wave in long submarine lines. Another essential difference between his and my system is, that he uses the opposed batteries only, and produces his signals by putting on an earth between them, while I do not put on an earth to produce the signal, but use a third source of electricity, viz., either an induction machine or another battery at the communicating station, whose poles are connected in the reverse direction to those of the tension battery; or the same effect may be produced by reversing the poles of the tension battery a^1 by a key, similar in principle to that patented by me on the 16th day of February 1854, No. 371.

Another feature of my Invention consists in preventing the burning at the relay contacts, or rather in lessening it. The burning roughens the surface of the platinum and the relays work irregularly in consequence, especially when the line current is weak; this I effect by attaching induction plates to the relay contact pieces, similar to those attached to the contact pieces of a Ruhmkorff's induction coil, which, being well known, I need not describe them further. The induction plates by reducing the spark reduce the destruction of the smooth surface of the platinum, and the machines will work a much longer time without attention and produce neater marks.

I modify my battery, patented on the 5th day of December 1854, No. 2555, as follows:—A portion of the metal plates is cut away so as to leave an opening through which crystals of negative salt can be dropped. The negative salt I sometimes coat with or grind up with gelatinous or gummy matters, such as common glue, &c., to cause them to be longer dissolving.

I claim, firstly, surrounding the coils of telegraph apparatus with iron, with the needle placed inside the coil, as at Figures 1, 2, 3, and 4,

Secondly, I claim, the general arrangement of the apparatus, shown in Figures 1, 2, 3, 4, 6, and 7.

I claim, thirdly, the arrangement of moving coils, shewn in Figures 8, 9, and 10, as adapted to telegraphic relays.

Fourthly, the use of aluminium wire in telegraphic moving coils.

Fifthly, the double-action galvanometer, shown at Figures 11 and 12.

Sixthly, the self-switching key, shown at Figure 13.

Seventhly, encasing induction coils with iron outside the primary or primary and secondary wires, for the purposes above stated.

Eighthly, placing a series of three or more flat induction coils side by side, so as to place the secondary wire for the most part between two primary wires, as at Figure 15.

Ninethly, wrapping the primary wire in parcels, as shown in Figure 16, the intervening spaces being filled with secondary wire.

Tenthly, the application to telegraphic purposes of electric currents obtained from induction machines by thermo-electricity.

Eleventhly, the use of glass, in the manner shown in Figures 17, 18, and 19, for insulating the primary from the secondary wire.

Twelfthly, the general arrangements of the induction machines, shown in Figures 17, 18, and 19.

Thirteenthly, the use of wire whose section is square or parallelopiped in the coils of telegraphic apparatus.

Fourteenthly, the use of wire in induction machines of progressively increasing thickness, as described, whereby the decreasing inductive action in the more distant coils is rendered as nearly equal as possible to that of the inner coils; I also claim the use of coils of wire of progressively increasing thickness for other telegraphic and magneto-electric apparatus.

Fifteenthly, the general arrangement of the keys, shown in Figures 20, 21, and 22.

Sixteenthly, the use of a series of three or more currents from an induction machine, to produce each mark or interval between the marks of recording telegraphs, as described, and represented at Figures 21 and 22.

Seventeenthly, the arrangement shown in Figures 23 and 24, for the purposes set forth.

Eighteenthly, the application for telegraphic purposes of electro-magnets covered with a metallic tube or secondary wire to retard their magnetisation, as described, and represented at Figure 25.

Nineteenthly, the application of "primary" coils to telegraphic lines to produce a momentary reversed current through the line after battery contact with the line has ceased.

Twentiethly, the disposition of apparatus, shown in Figure 27, for translating currents from one line to another, or for working a single line.

Twenty-firstly, the accelerating the passage of the electric wave through long submarine or subterranean wires by keeping them in a state of electric tension, as above described.

Twenty-second, the application of induction plates, similar to those used in Ruhmkorff's machines, to relays, whereby the burning is reduced and the action of the apparatus rendered more certain.

Twenty-thirdly, and lastly, I claim the above-described modifications of my battery, patented on the 5th day of December 1854, No. 2555.

In witness whereof, I, the said Cromwell Fleetwood Varley, have hereunto set my hand and seal, this Twenty-fourth day of June, in the year of our Lord One thousand eight hundred and fifty-seven.

CROMWELL FLEETWOOD VARLEY. (L.S.)

Witness,

ALEX. PRINCE, Agent for Patents,

4, Trafalgar Square.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1857.

FIG. 1.

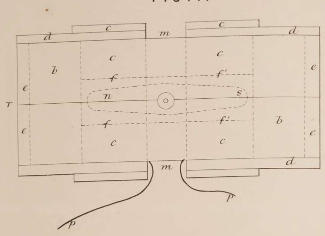

FIG. 11.

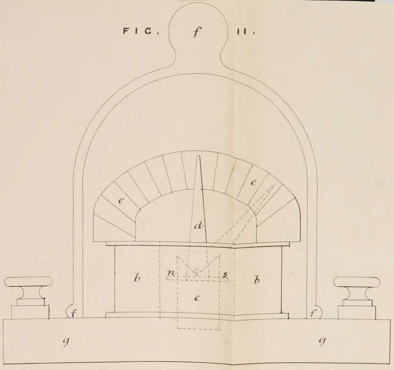

FIG. 12.

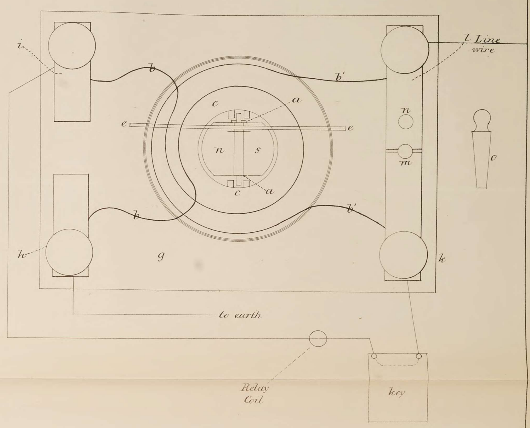

FIG. 2.

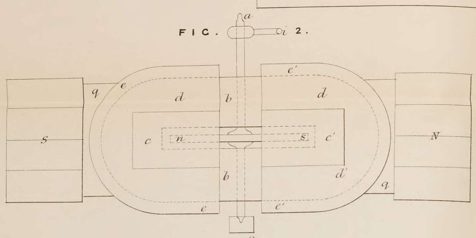

FIG. 5.

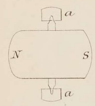

FIG. 8.

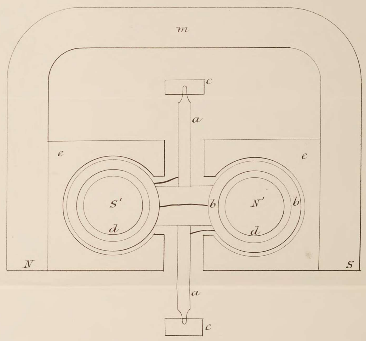

FIG. 3.

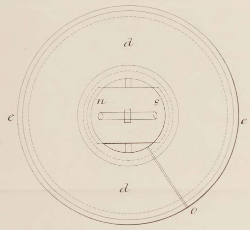

FIG. 4.

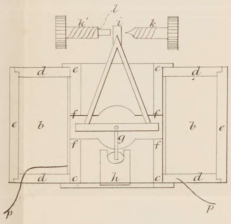

FIG. 9.

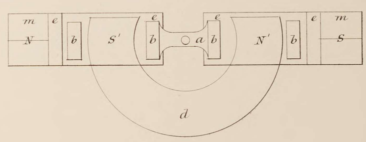

FIG. 6.

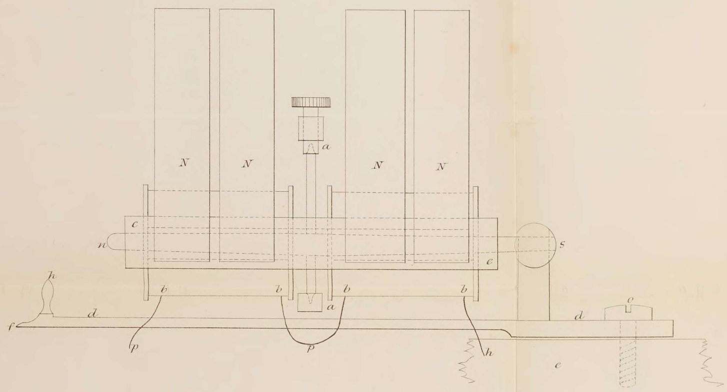

FIG. 10.

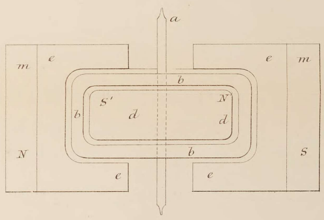

FIG. 7.